BAYOU PLAQUEMINE BRULE WATERSHED TMDL
TO ADDRESS DISSOLVED OXYGEN AND NUTRIENTS
INCLUDING EIGHT POINT SOURCE WASTELOAD ALLOCATIONS
AND A WATERSHED NONPOINT SOURCE LOAD ALLOCATION

SUBSEGMENT 0502

VOLUME I

TMDL Report
Appendix A-D

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EXECUTIVE SUMMARY

A TMDL for dissolved oxygen has been developed for the Bayou Plaquemine Brule Watershed based on hydrologic and water quality data available as of March, 1999. Bayou Plaquemine Brule was listed on both the 1996 and 1998 Section 303(d) Lists as not meeting the water quality standard for dissolved oxygen. Bayou Plaquemine Brule was ranked as a high priority (priority 1) on both lists for development of a TMDL. This waterbody was also listed as impaired due to nutrients. This TMDL establishes load limitations for oxygen-demanding substances and goals for reduction of those pollutants. LDEQ's position, as supported by the ruling in the lawsuit regarding water quality criteria for nutrients (Sierra Club v. Givens, 710 So.2d 249 (La. App. 1st Cir. 1997), writ denied, 705 So.2d 1106 (La. 1998), is that when oxygen-demanding substances are controlled and limited in order to ensure that the dissolved oxygen criterion is supported, nutrients are also controlled and limited. The implementation of this TMDL through wastewater discharge permits and implementation of best management practices to control and reduce runoff of soil and oxygen-demanding pollutants from nonpoint sources in the watershed will also control and reduce the nutrient loading from those sources.

The Bayou Plaquemine Brule watershed is segment 0502 of the Mermentau River Basin (Basin 5). Segment 0502 is comprised of Bayou Plaquemine Brule and all tributaries, including Hazelwood Gully, Coles Gully, Long Point Gully, Bayou Wikoff, Bayou Blanc and North Coulee Trief. It is projected that compliance with dissolved oxygen criteria will require a 50 percent reduction of man-made nonpoint loading in the watershed and more stringent limitations for three point source dischargers as follows:

		Permit limitations (BOD_5/NH_3-N/DO)		Projected limits (BOD_5/NH_3-N/DO)	
Facility	Flow (mgd)	Summer	Winter	Summer	Winter
Church Point POTW	0.80	10/2/6	10/10/6	10/2/5	20/10/6
Atwood Acres STP	.046	20/-/-	---	10/5/5	30/15/6
Acadian Fine Foods STP	.025	20/-/-	---	20/10/2	30/15/2
North Rayne POTW	.020	20/-/-	---	20/10/2	30/15/2
Crowley High School POTW	.034	30/-/-	---	10/5/5	30/15/6
Crowley POTW	2.47	5/2/5	10/2/5	5/5/5	10/5/6
Rayne POTW	1.50	10/-/-	---	10/5/5	10/5/6
Estherwood POTW	.080	10/-/-	---	10/10/2	30/15/2

There are 66 known dischargers in subsegment 0502, the majority of which are too small to have a significant impact on the watershed model. Limits for these small facilities are generally set by state policy. Current permit information and discharge monitoring reports were reviewed for all of these facilities, and only 8 were considered to have the potential to impact Bayou Plaquemine Brule. The eight facilities above were included in the model based upon their expected or design discharge.

Bayou Plaquemine Brule was modeled from its headwaters (River Kilometer 70.20) to its confluence with Bayou des Cannes (River Kilometer 0.0). Tributaries that received one of the named facilities were modeled from the facility to their confluence with Bayou Plaquemine Brule. Other tributaries were modeled as point sources. Both point and nonpoint source loads were represented in the model; those nonpoint source loads including headwater loading, nonpoint loading associated with flow, benthic sediment oxygen demand and resuspension, and other nonpoint loading not associated with flow.

The various spreadsheets that were used in conjunction with the modeling program may be found in the appendices in the order in which they were used. The flow calibration was based on measurements taken during the Church Point, Rayne, and Crowley surveys, and on a correlation of those measured flows with drainage area. Water quality calibration was also based on measurements taken during these surveys plus water quality data from the Estherwood ambient monitoring station and a 1998 assessment site near Egan. Projections were adjusted to meet the dissolved oxygen criteria by reducing both point source and nonpoint source loading to obtain wasteload and load allocations. Additional projections were run with point source concentrations backed off by one level of treatment. Except where the point source concentrations were already at secondary, the additional runs violate criteria in both summer and winter, indicating that the WLA levels of treatment are the least stringent levels projected to meet criteria.

Land use in the Bayou Plaquemine Brule watershed is fairly homogeneous, comprising principally rice farming, row crops, and pasture. TMDLs have therefore been calculated for the entire watershed and are as follows:

Summer Season (Mar – Nov) TMDLs

	UCBOD (lbs/day)	UNBOD (lbs/day)	MOS (lbs/day)	Total (lbs/day)	% of Total
Church Point POTW	153	57.4	52.7	263	
Atwood Acres STP	8.8	8.3	4.3	21.4	
Acadian Fine Foods STP	9.6	9.0	4.7	23.3	
North Rayne POTW	13.2	12.4	6.4	32.0	
Crowley High School POTW	4.6	4.3	2.2	11.1	
Crowley POTW	237	443	170	850	
Rayne POTW	288	269	139	696	
Estherwood POTW	7.7	14.4	5.5	27.6	
Total point source allocations (WLA)	722	818	385	1,924	9.1
	UCBOD (lbs/day)	UNBOD (lbs/day)	SOD (lbs/day)	Total (lbs/day)	
Nonpoint Load	9,949	6,167	3,099	19,216	
Headwater Load	53	34		87	
Load Allocation (LA)	10,002	6,201	3,099	19,303	90.9
Percent Reduction of man-made nonpoint				50	
Nonpoint source margin of safety (MOS)				0	
Total maximum daily load (TMDL)				21,227	100

Winter Season (Dec – Feb) TMDLs

	UCBOD (lbs/day)	UNBOD (lbs/day)	MOS (lbs/day)	Total (lbs/day)	% of Total
Church Point POTW	307	287	148	742	
Atwood Acres STP	26.5	24.8	12.8	64.2	
Acadian Fine Foods STP	14.5	13.5	7.0	34.9	
North Rayne POTW	19.8	18.5	9.6	48.0	
Crowley High School POTW	13.8	12.9	6.7	33.4	
Crowley POTW	474	443	229	1,146	
Rayne POTW	288	269	139	696	
Estherwood POTW	23.1	21.6	11.2	55.9	
Total point source allocations (WLA)	1,166	1,090	564	2,820	13.1
	UCBOD (lbs/day)	UNBOD (lbs/day)	SOD (lb/day)	Total (lbs/day)	
Nonpoint Load	9,978	6,194	1,661	17,832	
Headwater Load	530	339		869	
Load Allocation (LA)	10,508	6,533	1,661	18,701	86.9
Percent Reduction of man-made nonpoint				50	
Nonpoint source margin of safety (MOS)				0	
Total maximum daily load (TMDL)				21,521	100

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1. Introduction

Bayou Plaquemine Brule, Segment 0502 of the Mermentau Basin, was listed on both the 1996 and 1998 303(d) Lists as being impaired due to organic enrichment/low DO and requiring the development of a total maximum daily load (TMDL) for dissolved oxygen. It was ranked as a high priority (priority 1) for development of a TMDL on both lists. This waterbody was also listed as impaired due to nutrients. This TMDL establishes load limitations for oxygen-demanding substances and goals for reduction of those pollutants. LDEQ's position, as supported by the ruling in the lawsuit regarding water quality criteria for nutrients (Sierra Club v. Givens, 710 So.2d 249 (La. App. 1st Cir. 1997), writ denied, 705 So.2d 1106 (La. 1998), is that when oxygen-demanding substances are controlled and limited in order to ensure that the dissolved oxygen criterion is supported, nutrients are also controlled and limited. The implementation of this TMDL through wastewater discharge permits and implementation of best management practices to control and reduce runoff of soil and oxygen-demanding pollutants from nonpoint sources in the watershed will also control and reduce the nutrient loading from those sources. A calibrated water quality model for the Bayou Plaquemine Brule watershed was developed and projections run to quantify the point source wasteload allocations and nonpoint source load allocations required to meet established dissolved oxygen criteria. This report presents the model development and results.

1.1 Seasonality and Margin of Safety

The Clean Water Act requires the consideration of seasonal variation of conditions affecting the constituent of concern, and the inclusion of a margin of safety (MOS) in the development of a TMDL. For the Bayou Plaquemine Brule TMDL, LDEQ has employed an analysis of long-term ambient data to determine critical seasonal conditions and used a combination of implied and explicit margins of safety.

Critical conditions for dissolved oxygen were determined for the Mermentau Basin using long-term water quality data from six stations on the LDEQ Ambient Monitoring Network and the Louisiana Office of State Climatology water budget. Graphical and regression techniques were used to evaluate the temperature and dissolved oxygen data from the Ambient Network and the run-off determined from the water budget. Since nonpoint loading is conveyed by run-off, this seemed a reasonable correlation to use. Temperature is strongly inversely proportional to dissolved oxygen and moderately inversely proportional to run-off. Dissolved oxygen and run-off are also moderately directly proportional. The analysis concluded that the critical conditions for stream dissolved oxygen concentrations were those of negligible nonpoint run-off and low stream flow combined with high stream temperature.

When the rainfall run-off (and nonpoint loading) and stream flow are high, turbulence is higher due to the higher flow and the temperature is lowered by the run-off. In addition, run-off coefficients are higher in cooler weather due to reduced evaporation and evapotranspiration, so that the high flow periods of the year tend to be the cooler periods. Reaeration rates are, of course, much higher when water temperatures are cooler, and BOD decay rates are much lower. For these reasons, periods of high loading are periods of higher reaeration and dissolved oxygen but not necessarily periods of high BOD decay.

LDEQ interprets this phenomenon in its TMDL modeling by assuming that the annual nonpoint loading, rather than loading for any particular day, is responsible for the accumulated benthic blanket of the stream, which is, in turn, expressed as SOD and/or resuspended BOD in the model. This accumulated loading has its greatest impact on the stream during periods of higher temperature and lower flow.

LDEQ simulated critical summer conditions in the Bayou Plaquemine Brule dissolved oxygen TMDL projection modeling by using the annual 7Q10 flow or 0.1 cfs, whichever is higher, for all headwaters, and 90th percentile temperature for the summer season. Incremental flow was assumed to be zero; model loading was from point sources, perennial tributaries, sediment oxygen demand, and resuspension of sediments. LDEQ simulated critical winter conditions by using the lowest of the monthly 7Q10 flow published for the winter months or 1 cfs, whichever was higher, for all headwaters, and 90th percentile temperature for the season. Again, incremental flow was assumed to be zero; model loading was from point sources, perennial tributaries, sediment oxygen demand, and resuspension of sediments. In addition, LDEQ assumes that all point sources are discharging at maximum capacity.

In reality, the highest temperatures occur in July-August, the lowest stream flows occur in October-November, and the maximum point source discharge occurs following a significant rainfall, ie., high-flow conditions. The combination of these conditions plus the impact of other conservative assumptions regarding rates and loadings yields an implied margin of safety which is estimated to be in excess of 10%. Over and above this implied margin of safety, LDEQ used an explicit MOS of 20% for point source loads but no MOS for nonpoint loads. The total MOS is estimated to exceed 12% for the Bayou Plaquemine Brule TMDL.

2. Study Area Description

2.1 Mermentau River Basin

The Mermentau River Basin is located in southwestern Louisiana, and it encompasses the prairie region of the state and a section of the coastal zone. The Mermentau River Basin is bounded on the north and east by the Vermilion-Teche River Basin, on the west by the Calcasieu River Basin, and on the south by the Gulf of Mexico. The Mermentau River Basin is approximately 3,710 square miles in area, excluding the gulf waters segment (Volume 4, Basin/Segment Boundaries and Inventories, State of Louisiana Water Quality Management Plan, 1987).

The slope of the land toward the Gulf is very gradual, and as a result, the streams in the Mermentau Basin are characteristically sluggish. Fish kills have been commonly reported throughout the basin. Because waterbodies in the basin have little gradient and sluggish flows, their reaeration potential is low (Volume 5, Water Quality Inventory, State of Louisiana Water Quality Management Plan, 1990).

It has been suggested that the water quality problems in the basin may be largely due to agricultural runoff and hydrologic modification. During April and May, large volumes of very turbid water have been observed flowing downstream in these waterbodies, and this has been associated with planting activities in adjacent rice fields (Volume 5, Water Quality Inventory, State of Louisiana Water Quality Management Plan, 1990).

2.2 Bayou Plaquemine Brule Watershed, Segment 0502

This area is typical of the basin with its low relief which is an ideal condition for agricultural use as documented in Table 1. Segment 0502 is comprised of Bayou Plaquemine Brule as the main stem with several tributaries. These tributaries include Hazelwood Gully, Coles Gully, Long Point Gully, Bayou Wikoff, Bayou Blanc and North Coulee Trief.

Average annual precipitation in the segment, based on the nearest Louisiana Climatic Station in Crowley is 56.91 inches based on a 30 year record (LSU State Office of Climatology). Land use in the Mermentau River Basin is largely agricultural, the primary crops being rice and soybeans. Originally, this area was covered by tall prairie grasses, among which there were scattered clumps of trees. (Soil Survey Acadia Parish Louisiana, USDA, SCS, Series 1959, No.15. Issued September 1962). In the segment under study, agricultural uses account for 89% of the total segment area. Land uses in Segment 0502 are shown in Table 1 below (Volume 6, Nonpoint Source Pollution, State of Louisiana Water Quality Management Plan, 1990).

Table 1. Land uses in Segment 0502 of the Mermentau River Basin

Land use	Acres	%
Urban	12,259	3.5
Extractive	1,838	0.5
Agricultural	316,160	89.0
Forest Land	13,475	3.8
Water	536	0.2
Wetland	10,450	2.9
Barren Land	484	0.1

2.3 Water Quality Standards

Water quality standards for the State of Louisiana have been defined (Louisiana Department of Environmental Quality, Environmental Regulatory Code, Part IX, Water Quality Regulations, Chapter 11, 1998). These include both general narrative standards and numerical criteria. General standards include prevention of objectionable color, taste and odor, solids, toxics, oil and grease, foam, and nutrient conditions as well as aesthetic degradation.

Designated uses for Bayou Plaquemine Brule from its headwaters to Bayou Des Cannes (waterbody subsegment 050201) include primary contact recreation, secondary contact recreation, propagation of fish and wildlife, and agriculture.

Bayou Plaquemine Brule is listed on both the 1996 and 1998 303(d) Lists as a waterbody requiring a dissolved oxygen TMDL. Section 303(d) of the Clean Water Act requires the identification, listing, ranking and development of TMDLs for waters that do not meet applicable water quality standards after implementation of technology-based controls. In accordance with the UAA conducted for the Mermentau River Basin, current dissolved oxygen criteria are shown in Table 2. The results of the

UAA were sent to EPA (LDEQ. Mermentau River Basin UAA. 1998. Adopted October 20, 1998. Approved by EPA January 7, 1999).

Table 2. Current Dissolved Oxygen Criteria

March-November	3.0 mg/L
December-February	5.0 mg/L

2.4 Discharger Inventory

The Bayou Plaquemine watershed includes 66 known dischargers, according to LADEQ's permit tracking system. Current permit information and discharge monitoring reports were reviewed for all of these facilities, and only 8 were considered to have the potential to impact Bayou Plaquemine Brule. The balance of the dischargers are located on tributaries and are too small to have an impact on the targeted waterbody due to the small load and the distance upstream. These dischargers are accounted for as nonpoint loading through the process of calibration. They fall within one of several state or regional policies that govern permit limitations. The eight larger facilities that were specifically included in this watershed model are listed below.

Table 3. List of Facilities

Facility Name	Permit Number
Town of Church Point STP	LA0038598
Atwood Acres Subdivision	LAG560020
Crowley High School	LAG540077
Acadian Fine Foods	LA0085723
N. Rayne WWTP – Sills Subdivision	LAG560010
City of Crowley STP	LA0041254
City of Rayne – Main STP	LA0039055
Village of Estherwood	LA0064530

Town of Church Point POTW

This facility treats municipal wastewater with an activated sludge system, sand filtration, post aeration, and ultraviolet disinfection. It has a design flow of 0.8 MGD (1.24 cfs, 0.035 cms). The average monthly permit limits for the summer and winter months are as follows:

Parameter	Summer Limit	Winter Limit
$CBOD_5$	10.0 mg/L	10.0 mg/L
TSS	15.0 mg/L	15.0 mg/L
NH_3-N	2.0 mg/L	10.0 mg/L
DO	6.0 mg/L	6.0 mg/L

Atwood Acres Subdivision STP

According to the application dated October 1, 1997, this subdivision includes 66 homes and has a maximum capacity of 115 homes. The wastewater treatment facility was designed for the maximum capacity of the subdivision. This resulted in a 46,000 gpd oxidation pond with disinfection by chlorination. Monthly permit limits for both BOD_5 and TSS are 20.0 mg/L.

Acadian Fine Foods STP

This discharger produces wastewater from its crawfish cooking and packaging processes. The peak crawfish-processing season is February through June. Other seafood products are processed during the remainder of the year. The average effluent discharge for the crawfish season is 25,000 gpd. The average effluent discharge for the remainder of the year is 3,000 gpd. The wastewater pretreatment process consists of a package, four station, settling and aeration system. An anaerobic treatment pond, aerobic aeration pond, aerobic filter/settlement pond, and a chlorinator follow this process. Permit limitations of 20 mg/L for both $CBOD_5$ and TSS are based upon statewide policy for dischargers with an effluent flow between 25,000 gpd and 50,000 gpd.

Crowley High School POTW

This discharger produces sanitary wastewater. Wastewater treatment utilizes an oxidation pond. The design flow was not listed in the State of Louisiana General Permit application dated June 22, 1993. The number of students and school personnel are stated in the application as 1,010 people. The resulting design flow is 20,200 gpd based upon the Sanitary Code for the State of Louisiana, Chapter XIII, Sewerage and Refuse Disposal. The permit limits are 30.0 mg/L for $CBOD_5$ and 30.0 mg/L for TSS.

N. Rayne POTW – Sills Subdivision

This discharger processes municipal wastewater received from the subdivision. The treatment process consists of an extended aeration package plant. The design flow is 34,400 gpd (0.053 cfs, 0.002 cms). The monthly average permit limit for both $CBOD_5$ and TSS is 20 mg/L.

City of Crowley POTW

This sewage treatment plant processes municipal wastewater. It incorporates artificial wetlands with a rock/reed filter system and oxidation pond. The design flow is 2.47 MGD (3.82 cfs, 0.11 cms). An expected flow of 1.08 MGD (1.67 cfs, 0.047 cms) was stated in the 1995 NPDES permit application. The design flow was used in the model projections. The summer and winter limits for the facility are provided in the following list. These limits were obtained from the Municipal water Pollution Prevention Plan dated May 29, 1998.

Parameter	Summer Limit	Winter Limit
$CBOD_5$	5.0 mg/L	10.0 mg/L
TSS	15.0 mg/L	15.0 mg/L
NH_3-N	2.0 mg/L	2.0 mg/L
DO	5.0 mg/L	5.0 mg/L

City of Rayne POTW

This discharger processes municipal wastewater. At the time of the survey of Bayou Blanc at Rayne, treatment was a mechanical activated sludge plant. The treatment process now consists of an aerated lagoon system. The design flow is 1.5 MGD (2.32 cfs, 0.066cms). The average monthly permit limit for $CBOD_5$ is 10.0 mg/L.

Village of Estherwood POTW

This facility treats municipal wastewater through the use of an overland flow system. The system consists of screens, a communutor, an aeration pond, a holding pond, a distribution system, sloped and vegetated terraces, a collection system and a chlorination system. The design flow is 0.08 MGD (0.12 cfs, 0.0035 cms). The permit limits are 10 mg/L for $CBOD_5$ and 15 mg/L for TSS.

2.5 Previous Studies and Other Data

Water quality data for this TMDL was obtained from an intensive Survey of Bayou Plaquemine Brule at Church Point conducted October 2-5, 1989, an intensive Survey of Bayou Plaquemine Brule at Crowley conducted August 29, 1993-September 2, 1993, an intensive Survey of Bayou Blanc at Rayne conducted July 18-23, 1993, the DEQ ambient monitoring station on Bayou Plaquemine Brule at Estherwood, Number 58010004, and measurements of Bayou Plaquemine Brule taken at assessment site number 0650 near Egan in 1998. Data from an intensive Survey of Bayou Plaquemine Brule at Crowley conducted September 18-21, 1989 was not used.

3. Model Documentation

3.1 Program Description

The modeling system used to simulate the Bayou Plaquemine Brule stream network was QUAL-TX, a steady-state one-dimensional water quality model developed by the Water Quality Standards and Evaluation Section of the Texas Water Commission. It is a modified version of QUAL-II. It incorporates modifications that Texas felt necessary for modeling Texas streams, including the Texas reaeration equation, a variable element size, and coding that allows multiple models to be linked so that they can be executed in a single run.

3.2 Model Schematic and Description

The Bayou Plaquemine Brule system was modeled according to the vector diagram on the following page. The modeled portion of Bayou Plaquemine Brule extended from river kilometer (RKM) 70.20 to

RKM 0.0. Everything above RKM 70.20 was input as headwaters. River kilometer 0.0 is located at the confluence of Bayou Plaquemine Brule and Bayou des Cannes. Eight permitted dischargers were specifically included in the system, and the five tributaries receiving those discharges were simulated by the model. Seven additional tributaries to Bayou Plaquemine Brule, which were believed to be perennial, were simulated as point source inputs.

For convenience, five unnamed tributaries were given names for the purpose of identification and documentation. The stream receiving the discharge from the Atwood Acres Subdivision treatment plant was named Atwood Gully and a second unnamed stream into which it flows was named Atwood Bayou. These two streams were simulated as a single stream with Atwood Bayou upstream of Atwood Gully simulated as a point source. The stream receiving the discharge from Acadian Fine Foods was named Sills Gully and a second unnamed stream into which it flows was named Sills Bayou. These two streams plus Bayou Wikoff were also simulated as a single stream with Sills Bayou upstream of Sills Gully and Bayou Wikoff upstream of Sills Bayou simulated as a point sources. The stream receiving the discharge from Crowley High Gully was named Crowley High Gully. The Bayou Blanc model included the simulation of a small lake. Roller Canal is a pumped withdrawal used to irrigate ricefields, and the pumps were not running at the time of the 1993 Bayou Plaquemine Survey This withdrawal was not simulated by the watershed model.

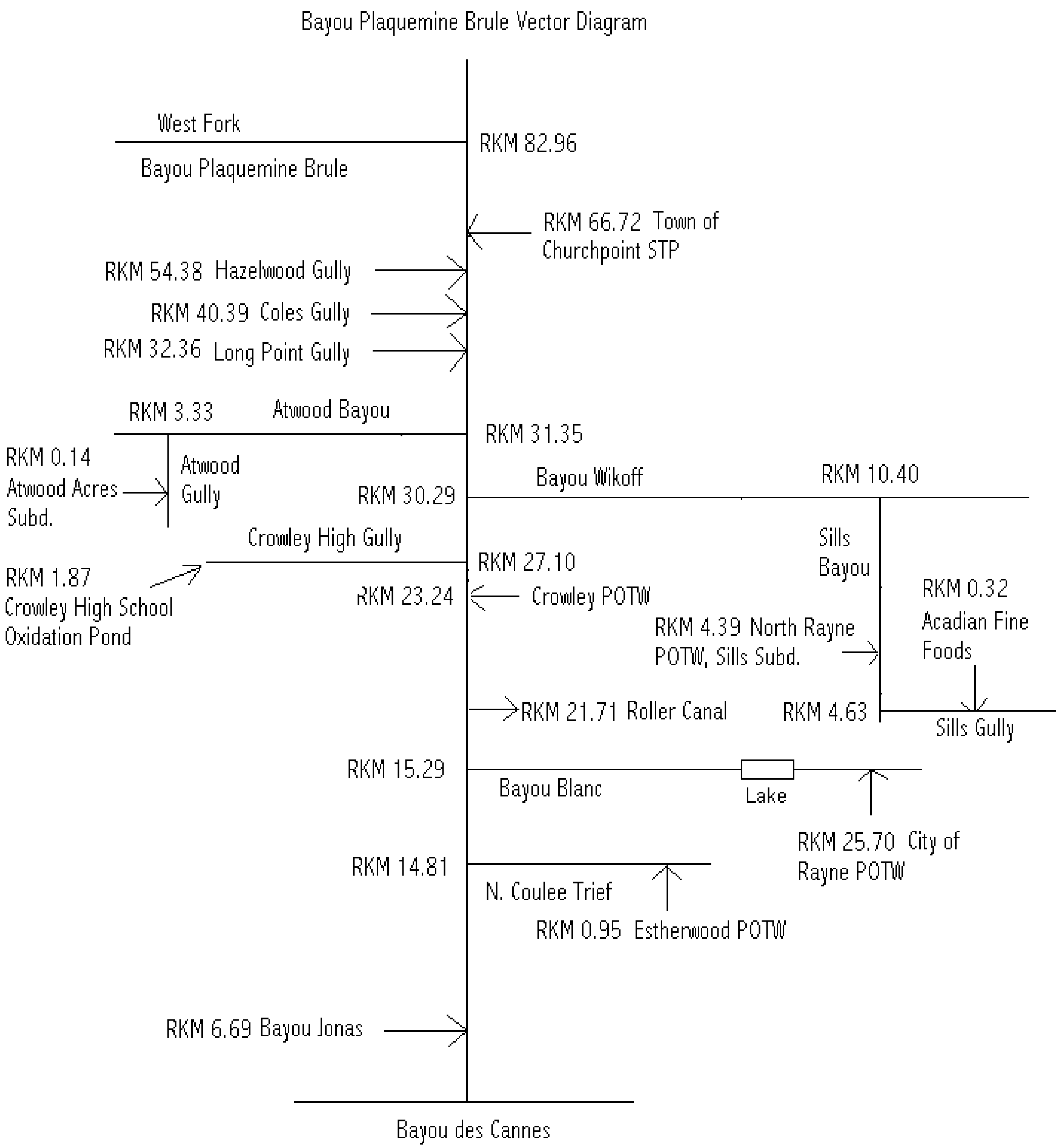

Figure 1. Vector Diagram of the Bayou Plaquemine Brule Watershed

3.3 Calibration and Projection

The various spreadsheets that were used in conjunction with the modeling program may be found in the appendices in the order in which they were used and are described below. The flow calibration was based on measurements taken during the Church Point, Rayne, and Crowley surveys, and on a correlation of those measured flows with drainage area. Water quality calibration was also based on measurements taken during these surveys plus water quality data from the Estherwood ambient monitoring station and a 1998 assessment site near Egan. Projections were adjusted to meet the dissolved oxygen criteria by reducing both point source and nonpoint source loading to obtain wasteload and load allocations. Additional projections were run with point source concentrations backed off by one level of treatment. Except where the point source concentrations were already at secondary, the additional runs violate criteria in both summer and winter, indicating that the WLA levels of treatment are the least stringent levels projected to meet criteria.

3.3.1 Flow Calibration

1. Vector Diagram
   The vector diagram shows the main stem of Bayou Plaquemine Brule, the major tributaries, and significant dischargers.
2. Drainage Areas for the Bayou Plaquemine Brule Project
   The table lists drainage areas that were obtained from USGS or measured from 1:24,000 topographic maps. Included are areas of tributary headwaters, drainage areas at tributary mouths, and drainage areas at various points along Bayou Plaquemine Brule and major tributaries.
3. Drainage Area Versus Flow
   The spreadsheet lists the available flow data and corresponding drainage areas. The flows are taken from low flow surveys of Bayou Plaquemine Brule near Crowley, Bayou Blanc near Rayne, and Bayou Plaquemine Brule near Church Point. A plot of net flow (without POTW discharges) versus drainage area was used to provide estimated flow data where measured data were not available.
4. Drainage Area and Discharges
   The spreadsheet uses the relation between drainage area and flow developed in item 3 to calculate flow throughout the watershed where measured data are not available.
5. Reaches and Elements
   The spreadsheet lists the model reaches that were selected, and details the layout of elements. The columns for width, depth, characteristic flow, velocity, and Leopold equation constants are described by items 7 and 9.
6. Width and Depth Versus Drainage Area
   The spreadsheet lists characteristic width, depth, and drainage area for those few reaches for which data is available. The plots of width and depth versus drainage area were used to select widths and depths for some reaches for which no data were available.
7. Width and Depth Determinations
   The spreadsheet details the selection of widths and depths for the 26 model reaches. Some of the data were obtained from field measurements and some by measuring stream widths on 1:24,000

DRGs. Width to depth ratios were calculated for the available field data and used to estimate some depths. The relationships of item 6 were also used to select widths and depths.

8. Flow Calibration

    The spreadsheet was used to perform a preliminary flow calibration for the model using upstream, tributary, and point source flows. Distributed flow was varied to obtain calibration. A characteristic flow was calculated for each reach at the same point in each reach for which widths and depths were estimated. The incremental flow is simply the distributed flow times the reach length.

9. Reaches and Elements

    The columns containing widths and depths were filled in using data from item 7 and the characteristic flow from item 8. Velocity and the constants for the Leopold equations were then calculated. The Leopold equation exponents suggested by Leopold for "ephemeral" and "158 streams" were used without change and the coefficients and depth constant were obtained by calibration to the calibration run widths and depths. Where it was felt necessary to hold both width and depth constant (most of the main channel of Bayou Plaquemine Brule and the lowest reach of Bayou Blanc), the depth constant was set to the desired depth and the velocity exponent was set to 1.

10. Model Output File and Charts

    At this point the model input file was created and the model run. The model output confirmed the preliminary flow calibration and plots of flow versus stream distance from mouth were printed. The measured and estimated (calculated) flow were overlaid on the flow plots to demonstrate calibration.

3.3.2 Water Quality Calibration

The basic premise governing water quality calibration and projection is that the dominant oxygen demanding load in the watershed at low flow is from an accumulation of benthic material washed into the streams during periods of higher flow. This load is exerted as sediment oxygen demand and as resuspension of material from the bottom. The QUALTX model can accommodate both a baseline SOD and a steady state SOD from the settling of CBOD and NBOD. It is suspected that in most of the Mermentau Basin the accumulation of benthic material is considerable and that the settling of BOD at low flow as simulated by the model does not significantly alter the sediment oxygen demand. SOD was therefore not tied to settling in the execution of this model.

1. UBOD Plots
    a. The Church Point survey report did not include the calculation of ultimate BODs, so they were recreated from lab data (samples 5-CP-1, 2, 7, 8, 13, 14, 19, 20, 25, 26, 31, and 32). UCBODs were also calculated for Bayou Plaquemine Brule at Egan (samples AA02613 and AA03085).
    b. The initial DO for samples 31 and 32 was over saturation and the amount of oversaturation was deducted from the suppressed and non-suppressed BOD data and the UBODs recalculated as 31* and 32*. The recalculated UBODs were used in place of the original UBODs.
    c. It appears that the nitrification suppressant failed in the running of suppressed BOD for samples 5-CP-7 and 8, the Church Point POTW. The non-suppressed BOD results were analyzed using GSBOD to obtain UBODs of 66.5 and 72.4.

2. Church Point/Crowley/Rayne Model Rates and Concentrations
    a. The spreadsheet gives modeling rates used in the Church Point, Crowley, and Rayne wasteload allocations. The numbers are averages of the rates that coincide with each of the BPB TMDL reaches. These rates were used as a starting point for calibration in the affected reaches.
    b. The POTW effluent and headwater BOD and DO concentrations used by the Church Point/Crowley/Rayne models are also listed and are used in the Bayou Plaquemine Brule TMDL.
3. Water Quality Model Input
    The spreadsheet lists the input for calibration of the water quality model.
    a. Advective dispersion

        QualTx uses the equation $D_L = 18.53nuh^{5/6}$ for advective dispersion, where n is Mannings "n", u is the velocity in m/s, and h is the depth in m. In order to input dispersion rates of the order of magnitude that we are accustomed to in Louisiana, artificially high values of n must be input. The spreadsheet shows the values of n and the resulting dispersion rates used for non-tidal reaches. Advective dispersion did not play a significant role in the calibration.
    b. Tidal dispersion

        The tidal reaches are the bottom reach of Bayou Blanc and all of Bayou Plaquemine Brule except reach 1. A tidal dispersion rate calculated for Bayou Queue de Tortue based on a 1992 survey was used. That dispersion rate was calculated for a reach of Bayou Queue de Tortue from RM 22.5 to 30.7. The midpoint of that reach is 31 miles from the top of Lake Arthur and tidal dispersion in Bayou Plaquemine Brule was calibrated to the same value at the same distance from Lake Arthur. Values for the other reaches were obtained by interpolation with respect to stream distance from the top of the tidal portion of the bayou where dispersion is zero.
    c. Lower boundary conditions

        Lower boundary conditions were taken from the Mermentau River ambient monitoring station at Mermentau for the months of July through October, 1989 – 1993. UNBOD was calculated as TKN x 4.3 and UCBOD was estimated from TOC. A UCBOD/TOC ratio of 0.6 was obtained from data from the 1993 Bayou Plaquemine Brule survey at Crowley.
    d. Reaeration rates

        Except for those reaches where rates were measured, reaeration rates were calculated using the Louisiana Equation.
    e. Decay rates, settling rates, and SOD rates

        Initial rates were taken from existing models for Bayou Plaquemine Brule at Church Point and Crowley and Bayou Blanc at Rayne, and adjusted to calibrate to measured values of CBOD, NBOD, and DO.
    f. Incremental nonpoint (with flow)

        A number of measurements of CBOD/NBOD/DO were made of ricefield runoff during the Rayne survey. An average of these values was used to represent incremental nonpoint water quality.

g. Chlorophyll

The modeling program can calculate algal production from values of chlorophyll a. In two portions of the watershed where there was evidence of algal production (elevated pH and DO near or in excess of saturation) values of chlorophyll a were input to simulate that production. In one of those two cases a measured value of chlorophyll was available.

h. Nonpoint (without flow)

Nonpoint CBOD and NBOD was added to calibrate the model. This loading is assumed to represent the combined impact of resuspension of benthic material and other loading entering the water column without an associated flow.

4. Calibration Data

The two spreadsheets titled Calibration Data" contain measured TKN, UCBOD, UNBOD, and DO data from three intensive surveys, the ambient monitoring site at Estherwood, and an assessment site at Egan. The model was calibrated to this data.

5. Model Output File and Charts

The model was calibrated to the data of item 4 as demonstrated by the accompanying charts. The item 4 data actually used (Data as Input to Calibration Plots) is listed prior to the charts.

3.3.3 Flow Projections

At low flow conditions the twelve reaches of Bayou Plaquemine Brule below the City of Church Point have virtually no surface slope and are influenced by wind tides in Lake Arthur. The velocity in these reaches at calibration conditions ranged from .025 to .002 meters per second. It is therefore expected that the width and depth of the bayou in these reaches will not change between calibration and winter and summer low flow conditions. The equations that control width and depth have been adjusted to reflect these conditions. The equations are:

$$h = cQ^d + e \qquad v = aQ^b \qquad w = Q/vh$$

To fix the width and depth, we set c = 0, e = the depth, b = 1, and a = 1/wh. The equations for width and depth then become:

$$h = e \quad w = Q/aQh = 1/ae$$

The same relationship was used for the small lake through which Bayou Blanc flows. The level of this lake is controlled by a culvert at the sampling site below the lake.

The tributaries and Bayou Plaquemine Brule above Church Point are represented as free flowing waterbodies with width and depth varying with flow. The value of e is the estimated depth of the stream at zero flow, and d and b were set at the values obtained by Leopold for “ephemeral streams” except for Bayou Wikoff for which d and b were set to Leopold’s exponents for “158 streams”. The coefficients a and c were obtained by calibration.

3.3.4 Water Quality Projections

1. Reference Stream Nonpoint Loading
   It is the purpose of the projections to produce wasteload allocations (WLAs) for point source dischargers and percent reductions of anthropogenic loading (LAs) for nonpoint sources. In order to differentiate anthropogenic from background nonpoint some measure of background loading is needed. Toward that end, the available calculated loading from the reference stream program is listed.
2. Bayou Plaquemine Brule Calibration Benthic Loading
   Also needed for the calculation of percent reduction of nonpoint is the calibration benthic loading, calculated for each reach in this spreadsheet.
3. Headwater and Facility Projection Flows, Concentrations, and Loading
   a. Facilities were input at expected flow plus a 20% allowance for growth and a margin of safety (MOS). The headwater flows were input at 0.1 cfs for summer low flow conditions to keep the model from crashing. A summer critical headwater flow of 0.1 cfs was used for all headwaters except those with a zero drainage area.
   b. Bayou Plaquemine Brule at the Church Point USGS Site 080102 (drainage area 48.2 mi^2 = 124.84 km^2) is correlated with Bayou des Cannes at the Eunice USGS Site 0801000 (drainage area = 131 mi^2) per "Low-Flow Characteristics of Louisiana Streams", LA DOTD Office of Public Works and DOI USGS p. 82. The Bayou des Cannes average monthly 7Q10 for December to February is: December 0.3 cfs, January 2.4 cfs, February 3.5 cfs, average 2.4 cfs. The December – February flow at Church Point is estimated to be 2.4 cfs x 48.2/131 = 0.88 cfs. The wintertime default 1.0 cfs was used for Bayou Plaquemine Brule at Church Point as per the Louisiana Technical Procedures.
   c. The model was then run to obtain summer and winter depths and velocities for the recalculation of reaeration.
4. Reaeration data for Projections
   The Louisiana equation was used to calculate reaeration for the summer and winter runs.
5. Summer Projection Benthic Loading
   This spreadsheet calculates the percent reduction of summertime anthropogenic loading corresponding to the input SOD and nonpoint NBOD and CBOD that allowed the criteria to be met. All calculations were done at 20 ^{o}C so that the differing temperatures for calibration and projection would not bias the results. The percent reduction of anthropogenic loading is defined as [(calibration loading-background loading)-(projection loading-background loading)/(calibration loading-background loading)]. By trial and error, the point source and nonpoint source reductions needed to project that each reach would meet dissolved oxygen criteria were determined. A nonpoint load reduction of about 50 percent in the tributaries and the upper reaches of Bayou Plaquemine Brule and about 30 percent in the main channel of the Bayou were needed to project that criteria would be met.
6. Winter Projection Benthic Loading
   The above process was repeated for winter conditions using the same percent reduction of nonpoint that was found to be needed in the summer.
7. Headwater and Facility Projection Flows, Concentrations, and Loading
   The point source concentrations needed to meet DO criteria were entered in the spreadsheet and point source and headwater loads were calculated.

8. Lower Boundary Conditions
   Lower boundary conditions were calculated from current data from the Mermentau River ambient monitoring station at Mermentau for the winter (December – February) and summer (March – November) months. UNBOD was calculated as TKN x 4.3 and UCBOD was estimated from TOC. A UCBOD/TOC ratio of 0.6 was obtained from data from the 1993 Bayou Plaquemine Brule survey at Crowley.
9. Model Output File and Charts
   The model output and charts for summer and winter projections are provided. In addition, point source concentrations were backed off by one level of treatment as defined by the Louisiana Technical Procedures and additional runs made. Except where the point source concentrations were already at secondary, the additional runs violate criteria in both summer and winter.
10. Benthic loading for Summer No-load Projection
    The estimated natural background benthic loading for the summer no-load projection run is listed. The calibration CBOD, NBOD, and SOD are reduced by the ratio of calibration benthic load to natural background benthic load to get the no (man-made) load CBOD, NBOD, and SOD, except that zero CBOD and NBOD were not allowed. Where the calibration CBOD or NBOD were zero a small load was input and the SOD adjusted downward so that the sum of the natural background CBOD, NBOD, and SOD equaled the total background benthic.
11. Reaeration Data for Summer No-load Projections
    The reaeration rates were recalculated at stream flow conditions with point source discharges removed using the Louisiana equation.
12. Model output charts
    Model output charts for the summer no-load projection are provided. The projected dissolved oxygen is above 5.0 mg/l in the watershed except for a short lower reach of Bayou Blanc.
13. Summer and Winter TMDL Calculations
    Land use in the Bayou Plaquemine Brule watershed is fairly homogeneous, comprising principally rice farming, row crops, and pasture. TMDLs have therefore been calculated for the entire watershed. The spreadsheet sums loading from headwaters, point sources, nonpoint not associated with flow, and SOD.

3.3.5 Minimum Projection Dissolved Oxygen

Table 4 lists the minimum dissolved oxygen levels projected for each reach at summer and winter critical conditions.

Table 4. Minimum Dissolved Oxygen Levels

MINIMUM DISSOLVED OXYGEN LEVELS SUMMER AND WINTER PROJECTIONS					
REACH NUMBER	ID CODE	SUMMER PROJECTION		WINTER PROJECTION	
		ELEMENT NUMBER	CONCENTRATION (mg/L)	ELEMENT NUMBER	CONCENTRATION (mg/L)
1	PB	13 - 14	4.84	20	6.62
2	PB	21	4.30	21	6.39
3	PB	29	3.11	32 - 33	5.57
4	PB	94	4.20	81	6.81
5	PB	102	3.31	102	7.30
6	PB	103	3.27	104	6.95
7	AG	105	3.04	105	5.22
8	AB	140	3.39	140	6.96
9	PB	142	3.35	142	6.85
10	SG	145	3.74	145	8.23
11	SB	155 - 157	3.20	171 - 177	7.71
12	BW	204	3.72	204	7.30
13	PB	207	3.15	208	6.19
14	CG	210	3.13	209	5.35
15	PB	228	3.35	247	4.89
16	PB	255	3.62	255	5.00
17	BB	311	4.59	287	6.85
18	BB	315	3.71	315	7.49
19	BB	317	3.66	319 - 320	7.44
20	BB	321	3.73	373	6.62
21	BB	386	3.12	387	5.26
22	PB	390	3.71	393	5.42
23	CT	401	3.03	404	5.47
24	PB	405	3.74	432	5.20
25	PB	436 - 437	3.54	435	5.03
26	PB	439	3.66	439	5.32

3.3.6 Sensitivity Analysis

Sensitivity analysis was performed for the summer critical projection, with the following results:

Table 5. Summer Projection Sensitivity Analysis

	Variation of parameter	
	- 30 % or 2°C	+ 30 % or 2°C
Parameter	Percent change in minimum DO	
Reaeration	- 51.4	+ 31.6
Depth	- 32.1	+16.5
SOD	+ 23.2	- 24.1
Temperature	+ 16.9	- 14.4
K_d	+ 6.1	- 5.1
K_n	+ 5.0	- 4.2

Since reaeration and SOD are both sensitive to depth, we can say that the three most sensitive parameters are depth related. It is especially important, therefore, that stream hydrologic data be reasonably good. Data from the sensitivity runs may be found in the Bayou Plaquemine Brule summer projection sensitivity spreadsheet.

4. TMDLs and Allocations

Land use in the Bayou Plaquemine Brule watershed is fairly homogeneous, comprising principally rice farming, row crops, and pasture. TMDLs have therefore been calculated for the entire watershed. Table 6 lists the WLAs and LAs as total BOD and gives the percent reduction of man-made nonpoint loading that is required.. Non-point loading is the sum of UCBOD, UNBOD, and SOD. Table 7 lists the specific point source allocations in mg/l.

Table 6. Total Maximum Daily Loads

Summer Season (Mar – Nov) TMDLs

	UCBOD (lbs/day)	UNBOD (lbs/day)	MOS (lbs/day)	Total (lbs/day)	% of Total
Church Point POTW	153	57.4	52.7	263	
Atwood Acres STP	8.8	8.3	4.3	21.4	
Acadian Fine Foods STP	9.6	9.0	4.7	23.3	
North Rayne POTW	13.2	12.4	6.4	32.0	
Crowley High School POTW	4.6	4.3	2.2	11.1	
Crowley POTW	237	443	170	850	
Rayne POTW	288	269	139	696	
Estherwood POTW	7.7	14.4	5.5	27.6	
Total point source allocations (WLA)	722	818	385	1,924	9.1
	UCBOD (lbs/day)	UNBOD (lbs/day)	SOD (lb/day)	Total (lbs/day)	
Nonpoint Load	9,949	6,167	3,099	19,216	
Headwater Load	53	34		87	
Load Allocation (LA)	10,002	6,201	3,099	19,303	90.9
Percent Reduction of man-made nonpoint				50	
Nonpoint source margin of safety (MOS)				0	
Total maximum daily load (TMDL)				21,227	100

Winter Season (Dec – Feb) TMDLs

	UCBOD (lbs/day)	UNBOD (lbs/day)	MOS (lbs/day)	Total (lbs/day)	% of Total
Church Point POTW	307	287	148	742	
Atwood Acres STP	26.5	24.8	12.8	64.2	
Acadian Fine Foods STP	14.5	13.5	7.0	34.9	
North Rayne POTW	19.8	18.5	9.6	48.0	
Crowley High School POTW	13.8	12.9	6.7	33.4	
Crowley POTW	474	443	229	1,146	
Rayne POTW	288	269	139	696	
Estherwood POTW	23.1	21.6	11.2	55.9	
Total point source allocations (WLA)	1,166	1,090	564	2,820	13.1
	UCBOD (lbs/day)	UNBOD (lbs/day)	SOD (lb/day)	Total (lbs/day)	
Nonpoint Load	9,978	6,194	1,661	17,832	
Headwater Load	530	339		869	
Load Allocation (LA)	10,508	6,533	1,661	18,701	86.9
Percent Reduction of man-made nonpoint				50	
Nonpoint source margin of safety (MOS)				0	
Total maximum daily load (TMDL)				21,521	100

Table 7. Point Source Allocations

		Permit limitations ($CBOD_5/NH_3$-N/DO)		Projected limits ($CBOD_5/NH_3$-N/D	
Facility	Flow (mgd)	Summer	Winter	Summer	Winter
Church Point POTW	0.80	10/2/6	10/10/6	10/2/5	20/10/6
Atwood Acres STP	.046	20/-/-	---	10/5/5	30/15/6
Acadian Fine Foods STP	.025	20/-/-	---	20/10/2	30/15/2
North Rayne POTW	.020	20/-/-	---	20/10/2	30/15/2
Crowley High School POTW	.034	30/-/-	---	10/5/5	30/15/6
Crowley POTW	2.47	5/2/5	10/2/5	5/5/5	10/5/6
Rayne POTW	1.50	10/-/-	---	10/5/5	10/5/6
Estherwood POTW	.080	10/-/-	---	10/10/2	30/15/2

4.1 TMDL Calculations

An outline of the TMDL calculations is provided to assist in understanding the calculations in the Appendices.

- The natural background benthic loading was estimated from reference stream NBOD, CBOD, and SOD data.
- The calibration anthropogenic (man-made) benthic loading was determined as follows:
  - Calibration non-point CBOD and NBOD (resuspension), and SOD were summed for each reach as gm/m^2d to get the total calibration benthic loading.
  - The natural background benthic loading was subtracted from the total calibration benthic loading to get the total anthropogenic (man-made) calibration benthic loading.
- Projection runs were made with:
  - Point sources represented at 125% of design flow (based on Department of Health design criteria) to provide an explicit 20% margin of safety for point source loading.
  - Headwater flows at seasonal 7Q10 or 0.1(summer)/1.0(winter) cfs, whichever was greater.
  - Headwater concentrations of CBOD, NBOD, and DO at calibration levels.
- For each reach, the non-point CBOD and NBOD (resuspension), SOD, and point source limitations were adjusted to bring the projected in-stream dissolved oxygen in compliance with criteria. No

additional explicit margin of safety was employed for non-point loading. The loading capacity and percent reduction of non-point were calculated as follows:

- The total projection benthic loading at 20°C was calculated as the sum of projection NBOD, CBOD, and SOD expressed as gm/m^2d.
- The natural background benthic loading was subtracted from the total projection benthic loading to get the total anthropogenic (man-made) projection benthic loading.
- The total anthropogenic projection benthic loading was subtracted from the total calibration anthropogenic benthic loading and that number divided by the total calibration anthropogenic benthic loading to obtain the percent reduction of non-point loading needed to achieve the in-stream dissolved oxygen criteria.
- The total projection benthic loading for each reach was calculated as follows:
  - The projection SOD at 20°C was adjusted to stream critical temperature.
  - The projection CBOD, NBOD, and SOD were summed to get the total benthic loading at stream temperature critical in lb/d for each reach.

- The total stream loading capacity at stream critical temperature was calculated as the sum of:
  - Headwater CBOD and NBOD loading in lb/d.
  - Projection benthic loading for all reaches of the stream in lb/d.
  - Total point source CBOD and NBOD loading in lb/d.
  - The facility margin of safety.

The TMDL for the Bayou Plaquemine Brule watershed was set equal to the total stream loading capacity.

5. Conclusions

A TMDL for dissolved oxygen has been developed for the Bayou Plaquemine Brule Watershed based on hydrologic and water quality data available as of March, 1999. It is projected that compliance with the existing dissolved oxygen criteria of 3.0 mg/l will require a 50 percent reduction of man-made nonpoint loading in the watershed and more stringent limitations for three point source dischargers. Several dischargers are projected to require slightly less stringent limitations. The current permit limitations and projected levels of treatment are:

		Permit limitations (BOD_5/NH_3-N/DO)		Projected limits (BOD_5/NH_3-N/DO)	
Facility	Flow (mgd)	Summer	Winter	Summer	Winter
Church Point POTW	0.80	10/2/6	10/10/6	10/2/5	20/10/6
Atwood Acres STP	.046	20/-/-	---	10/5/5	30/15/6
Acadian Fine Foods STP	.025	20/-/-	---	20/10/2	30/15/2
North Rayne POTW	.020	20/-/-	---	20/10/2	30/15/2
Crowley High School POTW	.034	30/-/-	---	10/5/5	30/15/6
Crowley POTW	2.47	5/2/5	10/2/5	5/5/5	10/5/6
Rayne POTW	1.50	10/-/-	---	10/5/5	10/5/6
Estherwood POTW	.080	10/-/-	---	10/10/2	30/15/2

LDEQ will work with other agencies such as local Soil Conservation Districts to implement agricultural best management practices in the watershed through the 319 programs. LDEQ will also continue to monitor the waters to determine whether standards are being attained.

In accordance with Section 106 of the federal Clean Water Act and under the authority of the Louisiana Environmental Quality Act, the LDEQ has established a comprehensive program for monitoring the quality of the state's surface waters. The LDEQ Surveillance Section collects surface water samples at various locations, utilizing appropriate sampling methods and procedures for ensuring the quality of the data collected. The objectives of the surface water monitoring program are to determine the quality of the state's surface waters, to develop a long-term data base for water quality trend analysis, and to monitor the effectiveness of pollution controls. The data obtained through the surface water monitoring program is used to develop the state's biennial 305(b) report (*Water Quality Inventory*) and the 303(d) list of impaired waters. This information is also utilized in establishing priorities for the LDEQ nonpoint source program.

The LDEQ has implemented a watershed approach to surface water quality monitoring. Through this approach, the entire state is sampled over a five-year cycle with two targeted basins sampled each year. Long-term trend monitoring sites at various locations on the larger rivers and Lake Pontchartrain are sampled throughout the five-year cycle. Sampling is conducted on a monthly basis or more frequently if necessary to yield at least 12 samples per site each year. Sampling sites are located where they are considered to be representative of the waterbody. Under the current monitoring schedule, targeted basins follow the TMDL priorities. In this manner, the first TMDLs will have been implemented by the time the first priority basins will be monitored again in the second five-year cycle. This will allow the LDEQ to determine whether there has been any improvement in water quality following implementation of the TMDLs. As the monitoring results are evaluated at the end of each year, waterbodies may be added to or removed from the 303(d) list. The sampling schedule for the first five-year cycle is shown below.

1998 - Mermentau and Vermilion-Teche River Basins
1999 - Calcasieu and Ouachita River Basins
2000 - Barataria and Terrebonne Basins
2001 - Lake Pontchartrain Basin and Pearl River Basin
2002 - Red and Sabine River Basins

The Atchafalaya and Mississippi Rivers will be sampled continuously. The Mermentau and Vermilion-Teche Basins will be sampled again in 2003.

6. List of References

Water Quality Evaluation Commission. Updated December 3, 1990. *QUAL-TX User's Manual, Version 3.3*, Austin, TX: Water Quality Standards and Evaluation Commission, Texas Water Commission.

Water Quality Evaluation Commission, November. 1990. *Wasteload Evaluation Methodology*, Austin, TX: Water Quality Standards and Evaluation Commission, Texas Water Commission.

Rudolph, Mark A. Notes for overlay plots in QUAL-TX. Austin, TX: Water Quality Evaluation Commission, Water Quality Standards and Evaluation Commission, Texas Water Commission.

Greenberg, Arnold E., Lenore S. Clesceri, and Andrew D. Eaton. 1992. Standard Methods For the Examination of Water and Wastewater, 18th Edition. 1992. American Public Health Association, American Water Works Association, and Water Environment Federation.

Louisiana Department of Environmental Quality. 1996. State of Louisiana Water Quality Management Plan , Volume 5, Part B, *Water Quality Inventory*. LA DEQ Office of Water Resources, Water Quality Management Division, Baton Rouge, Louisiana, p. A-32.

Louisiana Department of Environmental Quality. 1998. Environmental Regulatory Code: Part IX. *Water Quality Regulations*. Baton Rouge, LA: LA DEQ Office of Water Resources, Water Quality Management Division. pp. 179.

Waldon, Michael G., Ph.D., *Louisiana Total Maximum Daily Load Technical Procedures, 1994*, CLIWS-WQR 91.10. March, 1994 (revised). Center of Louisiana Inland Water Studies (CLIWS), Department of Civil Engineering, University of Southwestern Louisiana, for the LA Department of Environmental Quality, Office of Water Resources, Water Pollution Control Division, Engineering Section.

Kniffen, Fred B., and Sam Bowers Hilliard. 1988. Louisiana, Its Land and People. Baton Rouge and London. Louisiana State University Press.

Forbes, Max J., Jr. 1980. *Low-Flow Characteristics of Louisiana Streams*. Baton Rouge. LA: United States Department of the Interior and Louisiana Department of Transportation and Development, Office of Public Works, Technical Report No. 22.

Sloss, Raymond. Reprinted 1991. *Drainage Areas of Louisiana Streams*. Baton Rouge, LA: U.S. Geological Survey and Louisiana Department of Transportation and Development.

State of Louisiana Department of Health and Human Resources. October 20, 1984. Sanitary Code, State of Louisiana, Chapter XIII Sewage and Refuse Disposal. Baton
Rouge, LA.

Leopold, Luna B., and Thomas Maddock, Jr. 1953. *The Hydraulic Geometry of Stream Channels and Some Physiographic Implications*. Washington, D.C.: United States Government Printing Office. Professional Paper No. 252.

Lee, Fred N., and Duane Everette. *A Compilation of 7 Day, 10-Year Discharges for 363 Louisiana Streamflow Sites*. Baton Rouge, LA: Prepared for the Louisiana Department of Environmental Quality, Water Pollution Control Division, Engineering Section.

Lee, Fred N., Duanne Everette, and Max Forbes. March 31, 1997. *Lowflow Statistics from the USGS Database Through 1993*. Baton Rouge, LA: Prepared for the Louisiana Department of Environmental Quality, Water Pollution Control Division, Engineering Section. pp. 103-104, 106.

Asuquo, Gibson E. April 8, 1994. *Survey Report for the Intensive Survey of Bayou Plaquemine Brule at Crowley, August 29, 1993 – September 2, 1993 (Final)*. Baton Rouge, LA: Office of Water Resources, Louisiana Department of Environmental Quality.

Engineering Section. April, 1991. *Survey Report for the Bayou Plaquemine Brule at Church Point Intensive Survey, October 2 – 5, 1989 (Final)*. Baton Rouge, LA: Water Pollution Control Division, Louisiana Department of Environmental Quality. Report No. DEQ-WPCD-89.03.

Rogers, Madeline. April 25, 1991. *Wasteload Allocation for the Bayou Plaquemine Brule at Church Point, Louisiana (Draft)*. Baton Rouge, LA: Center for Louisiana Inland Water Studies, Department of Civil Engineering for the Louisiana Department of Environmental Quality. Report No. CLIWS-WLA 90.37.

Waldon, Michael Gene, Ph.D, P.E. April 15, 1996 (Revised May, 1997). *Bayou Plaquemine Brule TMDL including WLA for Crowley*. Center for Louisiana Inland Water Studies, Department of Civil Engineering for the Louisiana Department of Environmental Quality, Water Pollution Control Division, Engineering Section. Report No. CLIWS-WQR 95.06.

Engineering Section. July, 1991. *Survey Report fort the Bayou Plaquemine Brule at Crowley Intensive Survey, September 18-21, 1989 (Final)*. Baton Rouge, LA: Water Pollution Control Division Office of Water Resources, Louisiana department of Environmental Quality. Report No. DEQ-WPCD-89.02.

Pilione, Tina. March 25, 1994. *Bayou Blanc, City of Rayne, Intensive Survey Report Conducted July 18-23, 1993 (Final)*. Baton Rouge, LA: Louisiana Department of Environmental Quality, Office of Water Resources, Engineering Section.

Smythe, E. deEtte. September 30, 1996. *Simulating Longitudinal Dispersion Using a Conservative Dye Indicator*. Prepared for the Louisiana Department of Environmental Quality, Water Pollution Control Division, Engineering Section. Report No. CLIWS-WQR 93.01.

Reed, Sherwood C., Ronald Crites, and E. Joe Middlebrooks. 1995. Natural Systems for Waste Mangement and Treatment, Second Edition. McGraw-Hill.

Thoman, Robert V., and John A. Mueller. 1987. Principles of Surface Water Quality Modeling and Control. Manhattan College: Harper Collins Publishers.

USGS Discharge Database

LADEQ Ambient Network Database

LADEQ Assessment network Database

Permit Tracking System (PTS)

Permit Files

DMR Database (Stephanie Braden)

APPENDIX A – MODEL SCHEMATIC

Vector.doc - Bayou Plaquemine Brule Vector Diagram

APPENDIX B – HYDROLOGIC CALIBRATION

Bpbdas.xls - Drainage Areas for the Bayou Plaquemine Project
AvsQ.xls - Drainage Area versus Flow
AvsQ.xls - Net Q vs A including Bayou Blanc at Highway 13
WshedQs.xls - Drainage Areas and Discharges
Reach13.xls - Reaches and Elements
W&DvsA.xls - Width and Depth versus Drainage Area
W&DvsA.xls/CombW-DA - Width vs Drainage Area for Sites on Bayou Plaquemine Brule and Bayou Blanc
W&DvsA.xls/CombD-DA - Depth vs Drainage Area for Sites on Bayou Plaquemine Brule and Bayou Blanc
W&D.xls - Width and Depth Determinations
FlowCal2.xls - Flow Calibration
AG_Qcal.xls - Atwood Gully/Atwood bayou Flow Calibration
SG_Qcal.xls - Sills Gully/Sills Bayou/Bayou Wikoff Flow Calibration
CHG_Qcal.xls - Crowley High Gully Flow Calibration
BB_Qcal.xls - Bayou Blanc Flow calibration
NCT_Qcal.xls - North Coulee Trief Flow Calibration

APPENDIX C – WATER QUALITY CALIBRATION

BODPlots.doc - BOD Analysis for Church Point: 5-CP-1
BODPlots.doc - BOD Analysis for Church Point: 5-CP-2
BODPlots.doc - BOD Analysis for Church Point: 5-CP-7
BODPlots.doc - BOD Analysis for Church Point: 5-CP-8
BODPlots.doc - BOD Analysis for Church Point: 5-CP-13
BODPlots.doc - BOD Analysis for Church Point: 5-CP-14
BODPlots.doc - BOD Analysis for Church Point: 5-CP-19
BODPlots.doc - BOD Analysis for Church Point: 5-CP-20
BODPlots.doc - BOD Analysis for Church Point: 5-CP-25
BODPlots.doc - BOD Analysis for Church Point: 5-CP-26
BODPlots.doc - BOD Analysis for Church Point: 5-CP-31
BODPlots.doc - BOD Analysis for Church Point: 5-CP-32
BODPlots.doc - BOD Analysis for Church Point: 5-CP-31*
BODPlots.doc - BOD Analysis for Church Point: 5-CP-32*
CP_BODs.doc - Church Point nonsuppressed BODs
BODPlots.doc - BOD Analysis for Bayou Plaquemine Brule near Egan: AA02613 T-650
BODPlots.doc - BOD Analysis for Bayou Plaquemine Brule near Egan: AA03085 T-650
WQ_Data2.xls - Rates and Concentrations from Prior Models and DMRs
WQ_In3.xls - Model Water Quality Input
CalData.xls - Bayou Plaquemine Brule Calibration Data
Model Output:
Calbtxt.doc - Word file from which the Qual-Txn text output file was printed
CalData.doc - Data as Input to Calibration Plots
Calbplt.doc - Word file from which 9 plots were printed
BPB @ Church Pt Rch 1-3
Bayou Blanc Rchs 17-21
BPB Rchs 1-26
Calaplt.doc - Word file from which 12 plots were printed
Atwood Rchs 7-8
Sills/Wikoff Rchs 10-12
Crowley High Rch 14
N. Coulee Trief Rch 23

APPENDIX D – WATER QUALITY PROJECTIONS

BenLoad10.xls / Ref NP - Reference Stream Nonpoint Loading
BenLoad10.xls / Ref NP - Bayou Plaquemine Brule Calibration Benthic Loading
ProjDat7.xls / F & C - Headwater and Facility Projection Flows, Concentrations, and Loads
ProjDat7.xls / K2 - Reaeration Data for Projections
BenLoad10.xls / Sum NP - Bayou Plaquemine Brule Summer Projection Benthic Loading
BenLoad10.xls / Win NP - Bayou Plaquemine Brule Winter Projection Benthic Loading

APPENDIX D1 – WATER QUALITY SUMMER PROJECTION OUTPUT AND CHARTS

Model Output:
SPRJA3TX.doc - Word file from which the Qual-Txn text output file was printed
SPRJB3PL.doc - Word file from which 9 plots were printed
BPB @ Church Pt Rch 1-3
Bayou Blanc Rchs 17-21
BPB Rchs 1-26
SPRJA3PL.doc - Word file from which 12 plots were printed
Atwood Rchs 7-8
Sills/Wikoff Rchs 10-12
Crowley High Rch 14
N. Coulee Trief Rch 23

APPENDIX D2 – WATER QUALITY WINTER PROJECTION OUTPUT AND CHARTS

Model Output:
WPRJA3TX.doc - Word file from which the Qual-Txn text output file was printed
WPRJB3PL.doc - Word file from which 9 plots were printed
BPB @ Church Pt Rch 1-3
Bayou Blanc Rchs 17-21
BPB Rchs 1-26
WPRJA3PL.doc - Word file from which 12 plots were printed
Atwood Rchs 7-8
Sills/Wikoff Rchs 10-12
Crowley High Rch 14
N. Coulee Trief Rch 23

APPENDIX E - WATER QUALITY PROJECTIONS WITH LESS STRINGENT LIMITATIONS

		Projected limits (BOD_5/NH_3-N/DO)	
Facility	Flow (mgd)	Summer	Winter
Church Point POTW	0.80	10/5/5	30/15/6
Atwood Acres STP	.046	10/10/5	30/15/2
Acadian Fine Foods STP	.025	30/15/2	30/15/2*
North Rayne POTW	.020	30/15/2	30/15/2*
Crowley High School POTW	.034	10/10/5	30/15/2
Crowley POTW	2.47	10/5/5	10/10/6
Rayne POTW	1.50	10/10/5	10/10/6
Estherwood POTW	.080	20/10/2	30/15/2

* No change

APPENDIX F – WATER QUALITY SUMMER NO-LOAD PROJECTIONS

BenLoad10.xls / Sum N0-load NP - Benthic Loading for Summer No-load Projection
ProjDat7.xls / No-load K2 - Reaeration Data for Summer No-load Projections
SPRNLBpl.doc - Word file from which 9 plots were printed
BPB @ Church Pt Rch 1-3
Bayou Blanc Rchs 17-21
BPB Rchs 1-26
SPRNLApl.doc - Word file from which 12 plots were printed
Atwood Rchs 7-8
Sills/Wikoff Rchs 10-12
Crowley High Rch 14
N. Coulee Trief Rch 23

APPENDIX G – TMDL CALCULATIONS

BenLoad10.xls / Summer TMDL - Summer TMDL Calculations
BenLoad10.xls / Winter TMDL - Winter TMDL Calculations
SENSIT1.xls - Bayou Plaquemine Brule Summer Projection Sensitivity Analysis

BAYOU PLAQUEMINE BRULE WATERSHED TMDL TO ADDRESS DISSOLVED OXYGEN AND NUTRIENTS INCLUDING EIGHT POINT SOURCE WASTELOAD ALLOCATIONS AND A WATERSHED NONPOINT SOURCE LOAD ALLOCATION

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Appendix D1-G

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